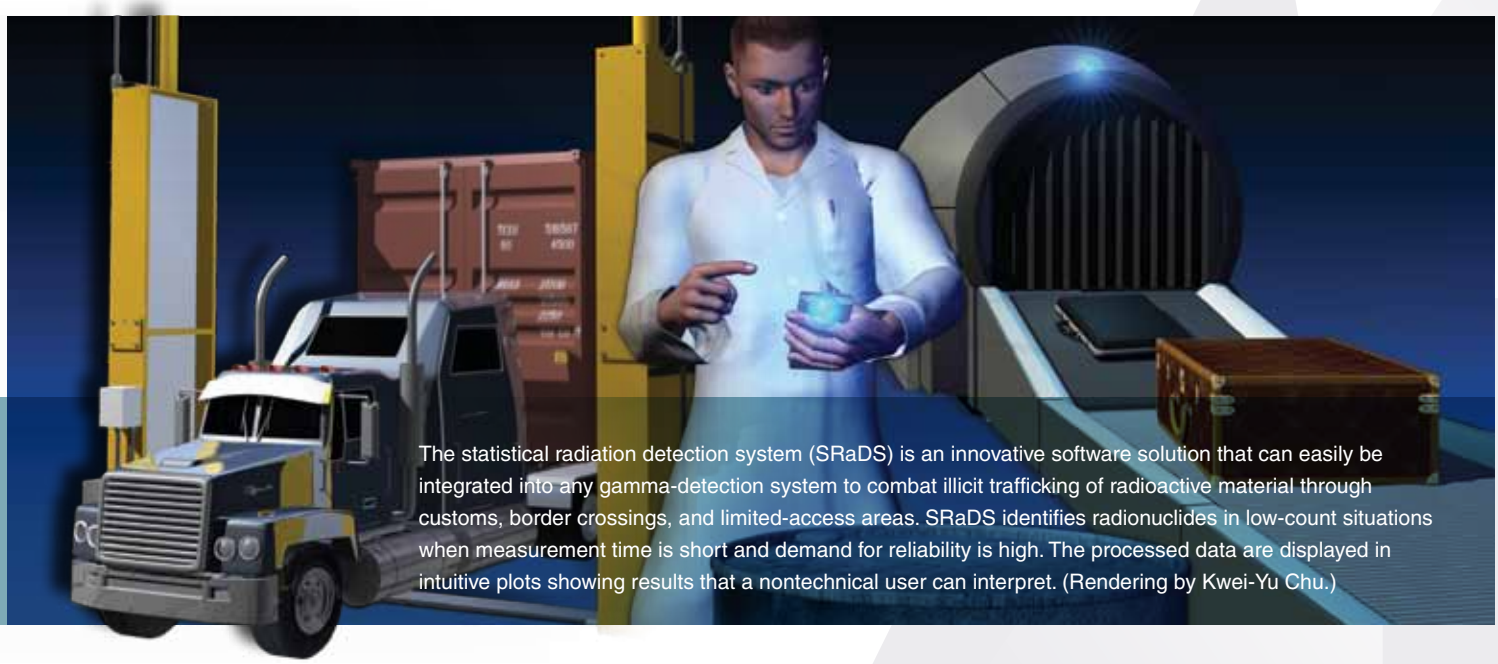

The statistical radiation detection system (SRaDS) is an innovative software solution that can easily be integrated into any gamma-detection system to combat illicit trafficking of radioactive material through customs, border crossings, and limited-access areas. SRaDS identifies radionuclides in low-count situations when measurement time is short and demand for reliability is high. The processed data are displayed in intuitive plots showing results that a nontechnical user can interpret. (Rendering by Kwei-Yu Chu.)

Software Solution for Radioactive Contraband Detection

EACH year, some 48 million cargo containers move among the world's transportation portals with more than 16 million containers arriving in the U.S. by ship, truck, and rail. Illicit radioactive materials could be hidden in any one of these cargo-filled containers. Yet, physically searching every container would bring shipping to a halt. Improving security at U.S. transportation portals is thus one of the nation's most difficult technical and practical challenges because the systems developed for screening cargo must operate in real time without disrupting legitimate commercial shipping activities.

Working at this intersection of commerce and national security, a team of Livermore scientists and engineers led by principal investigator James Candy applied its expertise in radiation science and gamma detection to develop the statistical radiation detection system (SRaDS), an innovative software solution that nonexperts can use to rapidly and reliably detect radionuclides. The team, along with ICx® Technologies, Inc., in Arlington, Virginia, has won an R&D 100 Award for the technology. According to Candy, who derived early support from Livermore's Laboratory Directed Research and Development Program, "the team cross-fertilized the areas of statistical signal processing with radiation transport physics, enabling a unique and breakthrough solution to a long-troubling problem, especially in today's climate of terrorist threats."

Development team for SRaDS: (from left) Brian Guidry, Kenneth Sale, Michael Axelrod, Thomas Gosnell, James Candy, Sean Walston, David Chambers, Eric Breitfeller. (Not shown: Dennis Slaughter, Jerome Verbeke, and Stanley Prussin [UCB].)

Rapid and Reliable Radionuclide Detection

Identifying radioactive material in a moving target is a difficult problem primarily because of the very low counts of gamma-ray signals during the short time interval for detection. In low-count situations such as these, conventional spectrometry techniques do not have enough time to collect the number of protons required to calculate the pulse-height spectra that identify radioactive materials. For example, a vehicle moving through a gamma-detection system at a transportation portal is screened for less than 10 seconds. Accurate radionuclide detection is even more difficult when radioactive material is shielded by lead, packaging, or adjacent cargo.

SRaDS speeds up identification by automatically rejecting extraneous and nontargeted photons during the process. Exploiting Bayesian algorithms, the smart processor examines each photon—one by one—as it arrives and then "decides" whether a detected radionuclide is present based on selected parameters. This capability is not available in conventional detection systems, yet it is essential in the successful identification of radionuclides in low-count situations when measurement time is short and demand for reliability is high.

When a cargo container arrives at an SRaDS detector, a decision function in the software is refreshed, updated, and refined based on the energies and arrival times of the accepted photons. Detection is declared only when statistically justified according to three factors—the Bayesian algorithms, the updated decision function, and the conditions defined by the specific receiver-operating characteristic curve obtained during initial calibration. In contrast, conventional techniques require manually setting a specific counting time in advance with the hope that the data acquired can justify the decision. By encompassing the statistical nature of radiation transport physics and sequential Bayesian processing techniques, SRaDS provides highly developed quantitative statistical analysis of the data received in real time.

What's more, basic and advanced processor options are available with SRaDS. Both processor options provide complete statistical analysis of radionuclide data obtained from any type of gamma detector. The basic and advanced processors gather information from unscattered photons that deposit full photon energy. The advanced processor also gathers information from Compton-scattered photons that exhibit diminished energy—a major breakthrough in time-domain low-count detection technology.

Integrates into Any Gamma-Detector System

The Livermore team took special care to ensure that SRaDS can easily be integrated into any gamma-detection system, including large stationary detectors at transportation portals that help search for contraband radioactive material in moving vehicles, cargo containers, and railroad cars. SRaDS works equally well in pedestrian monitors used to combat illicit trafficking of radioactive material through customs, border crossings, and limited-access areas. The technology can also be installed in portable gamma detectors used by first responders to determine radiation risks associated with local nuclear emergencies. The algorithms are easily embedded in programmable gate arrays that users can adjust in the field to a location's specifications and detection requirements.

Depending on the hardware setup, the processed data can be graphically displayed on a computer monitor or portable unit. While conventional gamma-detection systems require a highly trained practitioner to analyze the results, refine the data, and guide the interpretation procedure, SRaDS displays data in intuitive plots showing results that a nontechnical user can interpret. Alternatively, SRaDS can be configured to simply provide audio and visual alerts indicating the presence of targeted radionuclides at user-selected confidence levels. Users can also select false-alarm probabilities to reduce or eliminate the occurrence of false positives depending on the level of detection required for a given situation.

The result is a comprehensive software system that combines outstanding radionuclide-detection performance with high reliability and a short acquisition time. SRaDS can easily be implemented in existing infrastructure to protect the nation from the insidious threat of illicit radioactive materials.

—Geri Freitas

Key Words: Bayesian processing techniques, cargo container, gamma detector, R&D 100 Award, radionuclide detection, statistical radiation detection system (SRaDS).

For further information contact James Candy (925) 422-8675 (candy1@llnl.gov).